International Journal of Nutrology
(Official Journal of the ABRAN - Brazilian Association of Nutrology)

REVIEW ARTICLE

DOI: 10.54448/ijn23302

Healthy longevity: a systematic review of nutrological and lifestyle aspects

Rodrigo Augusto Carvalho Junqueira[1]*, Alexandre Carli Pinto[1]

[1] Dr. Rodrigo Junqueira Institute, Rio de Janeiro, Brazil.

*Corresponding Author: Dr. Rodrigo Augusto Carvalho Junqueira.
Instituto Dr. Rodrigo Junqueira, street: México, 41/Grupo 1307,
Rio de Janeiro, Brazil - CEP: 20031-905.
E-mail: racjunqueira@hotmail.com
DOI: https://doi.org/10.54448/ijn23302
Received: 05-18-2023; Revised: 07-19-2023; Accepted: 07-25-2023; Published: 08-03-2023; IJN-id: e23302

Abstract

Introduction: In the context of healthy longevity, quality of life, genetic, environmental, and lifestyle factors can determine the life expectancy of human beings. Nutrition is a key component affecting our health, and several studies show that nutrition also has the potential to increase lifespan. **Objective:** It was to carry out a systematic review of the impacts of nutrology and lifestyle on the longevity of human beings, as well as to point out the main dietary and lifestyle care based on the results of clinical studies. **Methods:** The systematic review rules of the PRISMA Platform were followed. The research was carried out from April to July 2023 in Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 311 articles were found, and 147 articles were evaluated and 47 were included in this systematic review. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 29 studies with a high risk of bias and 51 studies that did not meet GRADE. Most studies showed homogeneity in their results, with X^2 =87.3%>50%. There is scientific evidence that nutrients and natural substances of human physiology and biochemistry such as melatonin and coenzyme Q10 control the functions of the immune system. Many metabolic or chronic diseases have been implicated with poor diet and lifestyle. Improved diet quality is associated with reduced all-cause mortality, whereas multivitamins and multimineral supplements can improve life expectancy. Overall well-being is improved when sedentary but sufficiently physically active adults reduce sedentary time and increase physical activity levels. The results of the pandemic indicate there have been a variety of lifestyle changes, physical inactivity, and psychological issues. Still, adults over 40 years old, with children, unemployed, and those living in a macroeconomic region were shown to be more exposed to unhealthy behaviors. The maintenance of dietary intervention through telemedicine can reduce the negative impact of eating habits and physical activity patterns.

Keywords: Healthy Longevity. Nutrology. Nutrition. Lifestyle.

Introduction

In the context of healthy longevity, quality of life, genetic, environmental, and lifestyle factors can determine the life expectancy of human beings **[1]**. Nutrition is a key component affecting our health, and several studies show that nutrition also has the potential to increase lifespan. In humans, certain healthy foods are associated with longer telomere lengths. Furthermore, a high intake of whole grains, vegetables, fruits, nuts, and also coffee is associated with a reduced risk of all-cause mortality, while a high intake of red meat and especially processed meat is positively related to all-cause mortality **[2]**. Furthermore, Mediterranean and high-quality diets are associated with reduced risk of all-cause mortality **[3]**.

In this sense, preventive measures can radically change individuals' daily habits, including lifestyle-related behaviors **[2,3]**. In this respect, as an example, in the context of the COVID-19 pandemic, staying and working at home can affect diet, food choice, and access to food and thus reduce the possibilities and limit the practice of physical activity **[4,5]**. Thus, physical inactivity and obesity have been described as a global

public health problem **[6-8]**.

In this sense, the reduction of physical activity and lower energy expenditure can negatively affect physical and mental health **[9,10]**. In addition, the pandemic situation is also associated with emotions such as fear, sadness, and anxiety, which have been shown to reduce sleep quality **[10-12]**. Thus, WHO has developed guidelines to be adopted during home quarantine **[13]**.

Also, sedentary behavior, anxiety, and boredom caused by home confinement can influence the motivation to eat, change lifestyle patterns, reduce diet quality, and promote excessive consumption of high-calorie foods **[14,15]**. A healthy diet based on plant foods (vegetables and fruits), healthy fats, and foods low in fat and protein **[12,16]** along with adequate activity is the key strategy for supporting the immune system and curbing seasonal infections and viruses in the population **[17,18]**. Despite this, there is limited evidence to assess the effect of lockdowns and restrictions related to the COVID-19 pandemic on changes in dietary lifestyle behaviors **[19,20]**. Thus, changes in lifestyle and dietary behaviors may differ depending on socio-demographic factors, body weight, and changes in employment and family type during quarantine.

In this context, dietary supplementation with coenzyme Q10 (ubiquinone), melatonin, doses of vitamin C, vitamin D, minerals, short-chain fatty acids and omega-3 fatty acids, protein and carbohydrate content, Mediterranean diet and high-fiber diet can be beneficial in strengthening the immune response to fight SARS-CoV-2 infection and decrease inflammatory processes and the worsening of comorbidities such as hypertension, diabetes, obesity, chronic lung diseases, heart, liver and kidney diseases, tumors, clinically apparent immunodeficiencies, immunodeficiencies, such as early secretion capacity of type I interferon and pregnancy. Possible complications include acute respiratory distress syndrome, shock, disseminated coagulopathy, acute kidney injury, embolism, and secondary bacterial pneumonia **[21]**.

In this context, the role of nutrition in mental health is becoming increasingly recognized. Nutrition can be obtained from nutritional supplements such as polyunsaturated fatty acids (PUFAs), vitamins, minerals, antioxidants, amino acids, and pre/probiotic supplements **[22]**. A large number of meta-analyses have emerged examining nutritional supplements in the treatment of mental disorders. The strongest scientific evidence has been found for PUFAs (mainly eicosapentaenoic acid) as an adjunctive treatment for depression **[22]**.

More recent evidence has suggested that PUFAs may also be beneficial for attention-deficit/hyperactivity disorder. Additionally, folate-based supplements have been extensively researched as adjunctive treatments for depression and schizophrenia. There is also emerging evidence for N-acetylcysteine as a useful adjunctive treatment in mood disorders and schizophrenia. In this context, clinicians should be informed of nutritional supplements with established efficacy for certain conditions, such as eicosapentaenoic acid in depression **[22]**.

In this sense, nutritional knowledge can influence food choices and impact athletic performance. Valid and reliable measures are needed to assess the nutritional knowledge of athletes and coaches. However, the current status of nutritional knowledge in athletes and coaches is difficult to determine. Gaps in knowledge also remain, with the need for supplementation and the role of protein likely to be poorly understood. Past reports of nutrition knowledge need to be interpreted with caution. A new, universal, updated, and validated measure of general knowledge in sports nutrition is needed to allow the assessment of nutritional knowledge **[23]**.

Previous studies have shown that physical exercise and mindfulness meditation can lead to improved physical and mental health in athletes **[24]**. However, it is unclear whether these two forms of training share the same underlying mechanisms. Thus, one study compared two groups of older adults with 10 years of experience in mindfulness meditation (integrative mind-body training (IMBT)) or physical exercise (PE) to demonstrate their effects on the brain, physiology, and behavior. Healthy older adults were randomly selected from a large community health project and groups were compared on measures of quality of life, autonomic activity (heart rate, heart rate variability, skin conductance response, respiratory amplitude/rate), immune function (secretory immunoglobulin A, sIgA), stress hormone (cortisol), and brain imaging (resting-state functional connectivity, structural differences). Compared to EF, significantly higher ratings were found for the IMBT group in terms of quality of life. Parasympathetic activity indexed by skin conductance response and high-frequency heart rate variability also showed more favorable results in the IMBT group. However, the PE group had a lower baseline heart rate and greater thoracic respiratory amplitude. Baseline sIgA level was significantly higher and cortisol concentration was lower in the IMBT group. These findings suggest that the combination of physical and mental training can achieve better health outcomes and quality of life for the general population **[24]**.

Therefore, the present study aimed to carry out a systematic review of the impacts of nutrology and lifestyle on the longevity of human beings, as well as to point out the main dietary and lifestyle care based on the results of clinical studies.

Methods

Study Design

The systematic review rules of the PRISMA Platform (Transparent reporting of systematic review and meta-analysis were followed. Available at: www.prismastatement.org/. Accessed on: 06/17/2023.

Data Sources and Research Strategy

The search strategies for this systematic review were based on the keywords (MeSH Terms): *"Healthy Longevity. Nutrology. Nutrition. Lifestyle"*. The esearch was carried out from April to July 2023 in Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. In addition, a combination of keywords with the Booleans "OR", "AND" and the operator "NOT" were used to target scientific articles of interest.

Quality of Studies, Eligibility of Articles, and Risk of Bias

Studies were chosen that rigorously presented the results of the search process that presented scientific quality according to the GRADE classification, and that did not present a risk of significant bias, that is, that could compromise the safety of the results. According to GRADE recommendations, the quality of scientific evidence in the studies addressed was classified as high, moderate, low, or very low, according to the risk of evidence bias, sample size, clarity of comparisons, precision, and consistency in the effects of analyses. High-quality evidence was assigned using four criteria: 1) Randomized or prospective controlled clinical trials; 2) Retrospective clinical trials or case series; 3) Sample size greater than 15 participants; 4) Studies with statistically well-prepared results; 5) Studies published in indexed journals with a significant impact factor; 6) descriptive, interpretive, theoretical (credibility of methods) and pragmatic validity.

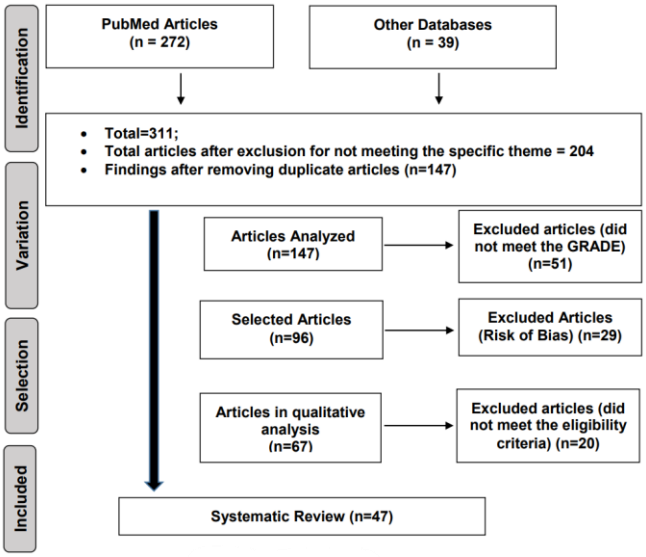
The Cochrane Instrument was adopted to assess the risk of bias in the selected studies using the Cohen Test to calculate the effect size - the magnitude of the difference in the results between the studies addressed in this study (Effect Size) versus the Inverse of the Standard Error (precision or sample size) to determine the Risk of Bias of the studies using the Funnel Plot chart.

Results and Discussion

Summary of Literary Findings

A total of 311 articles were found. Initially, duplication of articles was excluded. After this process, the abstracts were evaluated and a new exclusion was performed, removing the articles that did not include the specific theme of this article, resulting in 204 articles. After the duplicate article exclusion process, a total of 147 articles were evaluated and 47 were included and developed in this systematic review study (Figure 1). Considering the Cochrane tool for risk of bias, the overall assessment resulted in 54 studies with a high risk of bias and 51 studies that did not meet GRADE. Through the Chi-Square test (X^2), most studies showed homogeneity in their results, with X^2 =87.3% >50%.

Figure 1. Flowchart showing the article selection process.

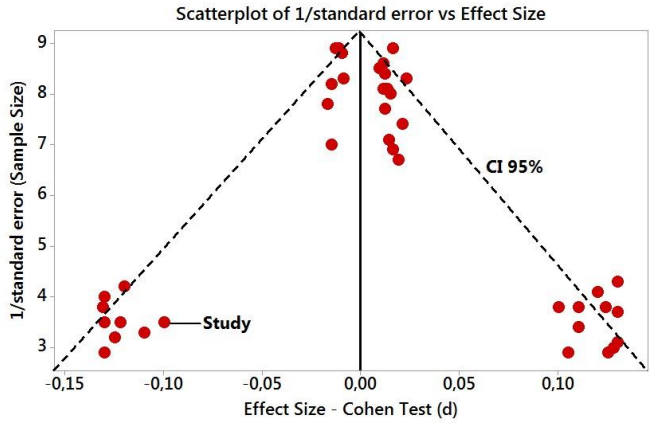


Source: Own authorship.

Figure 2 presents the results of the risk of bias of the studies through the Funnel Plot, showing the calculation of the Effect Size or Magnitude of the difference using the Cohen Test (d). The sample size was indirectly determined by the inverse of the standard error (1/Standard Error – Sample Size). This graph showed symmetrical behavior, not suggesting a significant risk of bias, both between studies with small sample sizes (lower precision) that are shown at the bottom of the graph and in studies with large sample sizes that are displayed in the upper region.

Figure 2. The symmetrical funnel plot does not suggest a risk of bias among the small sample size studies that are shown at the bottom of the plot. High confidence and high recommendation studies are shown above the

graph (NTotal = 47 clinical studies evaluated in full in the systematic review).



Source: Own authorship.

Major Outcomes – Nutrients, Lifestyle and Longevity

In the context of nutritional imbalance and its relationship with body and mind, nutrients of interest for cognitive health include polyunsaturated omega-3 fatty acids, polyphenols, vitamin D and B vitamins **[22]**. A review by the Scientific Advisory Committee on Nutrition (SACN) (2018) **[23]** suggested that the evidence is insufficient and inconclusive to support the idea that individual nutrients (vitamins C, E, and B vitamins, omega-3s, polyphenols, flavonoids, caffeine) could prevent cognitive decline.

Therefore, it remains to be demonstrated whether these individual nutrients are beneficial in preventing cognitive decline. It's difficult and it would be harmful to assume that a single nutrient can cure all diseases. Therefore, it is prudent to assert the synergistic relationship of nutrients to influence physiological and cognitive function. For example, it has been presumed that fish oils may be beneficial for brain health due to their omega-3 composition, but the oil and omega-3 evidence does not indicate that they would help preserve cognitive health **[24]**.

However, oily fish such as herring, mackerel, salmon, trout, and fresh tuna contain omega-3s as well as vitamin D, which may also support brain health and mediate cognitive decline. Low concentrations of vitamin D have been associated with accelerated decline in cognition across ethnicities. However, intake of vitamin D supplements in place of intake from dietary sources or exposure to sunlight for vitamin D remains to be demonstrated **[25]**.

Rather than individual nutrients, foods that contain these cognitive health nutrients could also benefit overall health and include fish, fruits, and vegetables **[22]**. Potentially shifting the focus to whole foods rather than individual nutrients would give recommendations more meaning. In this scenario, dietary regimes have been suggested as interventions to treat conditions such as hypertension, and dyslipidemia, the Mediterranean diet for metabolic syndrome and cardiovascular health **[26]**, and the Okinawan diet for healthy aging **[27]**.

The Mediterranean diet has been offered as a defense against ill health and as a means of healthy aging and cognitive health **[28]**. It is characterized by a high intake of extra virgin olive oil, vegetables including green leafy vegetables, fruits, whole grains, nuts, legumes, legumes, fish, dairy products, red wine, and a low intake of eggs and confectionery **[26]**. Numerous scores are available to measure adherence to the Mediterranean diet, but there is limited consensus on the criteria for scoring studies, despite being a useful tool for identifying dietary patterns **[29]**.

The two most commonly used scores are Trichopoulou et al (1995) **[30]** and Panagiotakos et al (2006) **[31]**. Trichopoulou et al. (1995) **[30]** derived the first Mediterranean diet adherence score for dietary patterns of elderly people in three Greek villages, which positively reflected life expectancy. However, Panagiotakos et al (2006) **[31]** derived their adherence score from the Mediterranean and compared it with biochemical data, demonstrating that the score was inversely associated with systolic blood pressure, C-reactive protein, total serum cholesterol, and oxidized low-density lipoproteins.

Furthermore, greater adherence to the Mediterranean diet has been associated with a reduced risk of cognitive decline and the development of Alzheimer's disease **[32,33]**. However, although the components of the Mediterranean diet are similar, the amounts and frequencies of consumption are inconsistent across studies, and mean adherence scores range from 23% to 88% **[26]**. In addition, most studies use variations in food frequency with different numbers of foods.

Additionally, certain amino acids are emerging as promising adjunct treatments for mind-body balance. Although the evidence is still incipient, N-acetylcysteine in particular (at doses of 2000 mg/day or more) is potentially effective for reducing depressive symptoms and improving functional recovery in mixed psychiatric samples **[34]**. Furthermore, significant reductions in total schizophrenia symptoms were observed when using N-acetylcysteine as an adjunctive treatment, albeit with substantial heterogeneity between studies, especially in study duration (in fact, N-acetylcysteine has a very late onset of action of about 6 months **[35,36]**.

Besides, N-acetylcysteine acts as a precursor of glutathione, the main endogenous antioxidant,

neutralizing cellular reactive oxygen and nitrogen **[37]**. Glutathione production in astrocytes is limited by cysteine. Oral glutathione and L-cysteine are broken down by first-pass metabolism and do not increase brain glutathione levels, unlike oral N-acetylcysteine, which is more easily absorbed and has been shown to increase brain glutathione in animal models. Furthermore, N-acetylcysteine has been shown to increase dopamine release in animal models **[38]**.

Furthermore, N-acetylcysteine may help in the treatment of schizophrenia, bipolar disorder, and depression by lowering oxidative stress and reducing glutamatergic dysfunction, but it has broader preclinical effects on mitochondria, apoptosis, neurogenesis, and telomere lengthening **[38]**.

While there are potential beneficial effects concerning the use of nutritional supplements, this should not replace dietary improvement. Improved diet quality is associated with reduced all-cause mortality **[39]**, whereas multivitamins and multimineral supplements can improve life expectancy **[40-42]**.

Also, the sports relative energy deficiency syndrome (RED-S) is a clinical entity characterized by low energy availability, which can negatively affect the health and performance of male and female athletes. The underlying mechanism of RED-S is an inadequacy of dietary energy to support optimal health and performance. This syndrome refers to impaired physiological function, including metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health, with psychological consequences that may precede (through restrictive eating habits) or result from RED-S **[43]**.

The term RED-S extends beyond the so-called "Female Athlete Triad". Formerly known as synchronized swimming, artistic swimming is an Olympic sport that requires a high level of physical conditioning in addition to technical skill and artistry. The risk of RED-S is high in artistic swimming, as it is an aesthetic, judged sport with an emphasis on a lean body. RED-S is a significant concern in the sport of artistic swimming due to potential negative effects on physical and mental health, as well as consequences on athletic performance. The prevention and management of RED-S in this population of athletes should be a priority for coaches, and sports medicine professionals working with artistic swimming athletes should utilize the RED-S CAT, a clinical assessment tool to screen and manage the RED-S **[43]**.

In this context, the construction of total well-being includes a holistic approach to the body, mind, and spirit components of life. While the health benefits of reducing sedentary behavior and increasing physical activity are well documented, little is known about the influence on the overall well-being of an Internet-based physical activity tracker designed to help people achieve more high levels of physical activity. Thus, a four-week, personal activity monitor-based intervention study was to reduce sedentary behavior and increase levels of physical activity in the daily lives of sedentary adults and determine whether these changes would also be associated with improved overall well-being. Twenty-two men and 11 women (27 years ± 4.0) were randomly assigned to an intervention (n = 18) or control group (n = 15). The intervention group interacted with an online personal activity monitor (Gruve Solution™) designed to reduce sedentary time and increase physical activity during activities of daily living. The control group did not interact with the monitor, as they were asked to follow their normal daily physical activities and sedentary behavior routines. The Lifestyle Well-Being Assessment Inventory was used to assess total well-being. Sedentary time, light physical activity, walking, and moderate and vigorous intensity were evaluated for the intervention and control groups at baseline and week 4, using the 7-day Record of Physical Activity for Sedentary Persons and Light Intensity. Therefore, overall well-being is improved when sedentary but sufficiently physically active adults reduce sedentary time and increase physical activity levels (ie, light, awake, moderate, and vigorous) **[44]**.

In recent years, the benefits of physical activity have drawn more attention to its physiological effects on the body, including well-being. The endocannabinoid system (ECS) has emerged as a focal point for determining the mechanisms of how exercise benefits the body and how it reduces or controls pain. ECS, its ligands [endocannabinoids (eCB)], receptors (CB1 and CB2), enzymes for eCB synthesis and degradation, and the polyunsaturated fatty acids that serve as substrates, comprise a powerful biological organization of multiple controls that affect mood, inflammation, pain, and other neurological aspects of the central and peripheral nervous systems. Recently, researchers have reported increases in circulating eCB levels after exercise, with some eCB exerting analgesic effects from exercise. Future research on ECS should include mechanistic approaches to endocannabinoid signaling and explain the role of dietary polyunsaturated fatty acids in altering the signaling of receptors that affect pain. Furthermore, like other types of exercise, such as Tai Chi, which are reported to improve well-being, they should be investigated to see whether changes in the eCB mediate the mind and body benefits of Tai Chi **[45]**.

Moreover, few nutritional supplements have scientifically demonstrated their effectiveness as an ergogenic aid. Thus, a review study examined creatine

monohydrate (CM), β-hydroxy-β-methylbutyrate (HMB), sodium bicarbonate (BS), β-alanine and caffeine concerning efficacy, mechanisms of action, dose, side effects, and some sports that can benefit from its consumption. Doses of 20 mg/day for 4-7 days are effective for improving strength, muscle power, and performance in short, repeated sprints. HMB in doses of 3 g/day for at least 2 weeks contributes to the increase in lean mass and fat-free mass. Ingestion of 0.3 g/kg of BS improves performance in tests from 400 to 1,500 meters in athletics and intermittent sprints. Meanwhile, doses of 80 mg/kg/day of β-alanine for 4-10 weeks may improve performance in high-intensity intermittent exercise. Finally, caffeine in doses of 2 mg/kg improves responsiveness and 3-6 mg/kg improves performance in endurance tests. The reviewed supplements showed their effectiveness in physical performance, but it is necessary to keep in mind that most of the studies were carried out with recreational-level athletes. Generally, the better the individual's fitness level, the less improvement in physical performance that the supplement shows. However, an increase of just 1% can sometimes allow the athlete to advance several positions in a final **[46]**.

Furthermore, mental fatigue is a psychobiological state caused by prolonged periods of demanding cognitive activity that has been shown to negatively influence physical performance. There is variation in the literature regarding the manifestations and impact of mental fatigue, with little knowledge of the specific manifestations of dominance in elite sports. Difficulties in defining mental fatigue may explain why it is not consistently assessed by training or support staff. Thus, one study investigated athletes' and officials' understandings of mental fatigue in elite sports. Nine focus group discussions were held, involving a total of 32 athletes (n = 17) and employees (n = 15) from elite sports organizations. Athletes and officials believe that mental fatigue negatively affects sports performance. The analysis revealed perceived associations between mental fatigue and changes in behavior, including demotivation, decreased motivation and enthusiasm, increased displays of emotion, and withdrawal. Changes in concentration, decreased discipline and attention to detail also emerged as descriptors of mental fatigue. Reports of media involvement, studies, and work commitments induced mental fatigue. Repetitive tasks, over-analyzing, thinking about the sport in question, and environmental instability were perceived causes. Experience and personality emerged as factors that contribute to individual susceptibility. It is noticed that mental fatigue not only develops acutely but also accumulates cumulatively in the elite sporting environment **[47]**.

Limitation

There is a lack of controlled randomized clinical studies with a large sample size to show the main nutrients and lifestyles that best impact healthy longevity.

Conclusion

There is scientific evidence that nutrients and natural substances of human physiology and biochemistry such as melatonin and coenzyme Q10 control the functions of the immune system. Many metabolic or chronic diseases have been implicated with poor diet and lifestyle. Improved diet quality is associated with reduced all-cause mortality, whereas multivitamins and multimineral supplements can improve life expectancy. Overall well-being is improved when sedentary but sufficiently physically active adults reduce sedentary time and increase physical activity levels. The results of the pandemic indicate there have been a variety of lifestyle changes, physical inactivity, and psychological issues. Still, adults over 40 years old, with children, unemployed, and those living in a macroeconomic region were shown to be more exposed to unhealthy behaviors. The maintenance of dietary intervention through telemedicine can reduce the negative impact of eating habits and physical activity patterns.

Acknowledgement

Not applicable.

Ethical Approval

Not applicable.

Informed consent

Not applicable.

Funding

Not applicable.

Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

Similarity check

It was applied by Ithenticate@.

References

1. Ekmekcioglu C. Nutrition and longevity - From mechanisms to uncertainties. Crit Rev Food Sci Nutr. 2020;60(18):3063-3082. doi: 10.1080/10408398.2019.1676698.
2. Dominguez LJ, Di Bella G, Veronese N, Barbagallo M. Impact of Mediterranean Diet on Chronic Non-Communicable Diseases and Longevity. Nutrients. 2021 Jun 12;13(6):2028. doi: 10.3390/nu13062028.
3. Friedman SM. Lifestyle (Medicine) and Healthy Aging. Clin Geriatr Med. 2020 Nov;36(4):645-653. doi: 10.1016/j.cger.2020.06.007.
4. World Health Organization (WHO). The top 10 causes of death. Disponível em: http://www.who.int/mediacentre/factsheets/fs310/en/. Accessed in: March. 2023.
5. COVID-19 Map—Johns Hopkins Coronavirus Resource Center. Available online: https://coronavirus.jhu.edu/map.html. Accessed on 18 April 2023.
6. Decree of the Minister of Health of 20 March 2020 Regarding the Announcement of the State of the Epidemic in the Territory of the Republic of Poland. Available online: http://prawo.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20200000491 Accessed on 2 April 2023.
7. Giustino V, Parroco AM, Gennaro A, Musumeci G, Palma A, Battaglia G. Physical Activity Levels and Related Energy Expenditure during COVID-19 Quarantine among the Sicilian Active Population: A Cross-Sectional Online Survey Study. Sustainability 2020, 12, 4356.
8. Ammar A, Brach M, Trabelsi K, Chtourou H, Boukhris O, Masmoudi L, Bouaziz B, Bentlage E, How D, Ahmed M et al. Effects of COVID-19 Home Confinement on Eating Behaviour and Physical Activity: Results of the ECLB-COVID19 International Online Survey. Nutrients 2020, 12, 1583.
9. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: A pooled analysis of 358 population-based surveys with 1·9 million participants. Lancet Glob. Health 2018, 6, e1077–e1086.
10. Finkelstein EA, Khavjou OA, Thompson H, Trogdon JG, Pan L, Sherry B, Dietz W. Obesity and severe obesity forecasts through 2030. Am. J. Prev. Med. 2012, 42, 563–570.
11. Ravalli S, Musumeci, G. Coronavirus Outbreak in Italy: Physiological Benefits of Home-Based Exercise During Pandemic. J. Funct. Morphol. Kinesiol. 2020, 5, 31.
12. Naja F, Hamadeh, R. Nutrition amid the COVID-19 pandemic: A multi-level framework for action. Eur. J. Clin. Nutr. 2020, 1–5.
13. Zhang Y, Zhang H, Ma X, Di Q. Mental Health Problems during the COVID-19 Pandemics and the Mitigation Effects of Exercise: A Longitudinal Study of College Students in China. Int. J. Environ. Res. Public Health 2020, 17, 3722.
14. Zabetakis I, Lordan R, Norton C, Tsoupras A. COVID-19: The Inflammation Link and the Role of Nutrition in Potential Mitigation. Nutrients 2020, 12, 1466.
15. Martinez-Ferran M, de la Guía-Galipienso F, Sanchis-Gomar F, Pareja-Galeano H. Metabolic Impacts of Confinement during the COVID-19 Pandemic Due to Modified Diet and Physical Activity Habits. Nutrients 2020, 12, 1549.
16. World Health Organization Stay Physically Active during Self-Quarantine. Available online:http://www.euro.who.int/en/health-topics/healthemergencies/coronavirus-covid-19/technical-guidance/stay-physically-activeduring-self-quarantine. Accessed on 20 April 2023.
17. Chaput JP, Klingenberg L, Astrup A, Sjödin AM. Modern sedentary activities promote overconsumption of food in our current obesogenic environment. Obes. Rev. 2011, 12, e12–e20.
18. Scully M, Dixon H, Wakefield M. Association between commercial television exposure and fast-food consumption among adults. Public Health Nutr. 2009, 12, 105–110.
19. World Health Organization Food and Nutrition Tips during Self-Quarantine. Available online: https://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/technicalguidance/food-and-nutrition-tipsduring-self-quarantine. Accessed on 15 April 2023.
20. Calder PC. Nutrition, immunity and COVID-19. BMJ Nutr. Prev. Health 2020.
21. Valdés-Ramos R, Martnez-Carrillo BE, Aranda-González II, Guadarrama AL, Pardo-Morales RV, Tlatempa P, Jarillo-Luna RA. Diet, exercise and gut mucosal immunity. Proc. Nutr. Soc. 2010, 69,

644–650.

22. Calder P, Carding S, Christopher G et al. A holistic approach to healthy ageing: how can people live longer, healthier lives? Journal of Human Nutrition and Dietetics. 2018, 31, 4, 439-450.
23. Scientific Advisory Committee on Nutrition (2018) SACN Statement on Diet, Cognitive Impairment and Dementia. 2018. www.gov.uk/government/publications/sacn-statement-on-diet-cognitive-impairmentand-dementia. Accessed: 22 May 2023.
24. Dangour A, Andreeva V, Sydenham E et al. Omega 3 fatty acids and cognitive health in older people. British Journal of Nutrition. 2012, 107, Suppl 2, S152S158.
25. Miller J, Harvey D, Beckett L et al. Vitamin D status and rates of cognitive decline in a multiethnic cohort of older adults. JAMA Neurology. 2015, 72, 11, 12951303.
26. Davis C, Bryan J, Hodgson J et al. Definition of the Mediterranean diet: a literature review. Nutrients. 2015, 7, 11, 9139-9153.
27. Willcox D, Scapagnini G, Willcox B. Healthy aging diets other than the Mediterranean: a focus on the Okinawan diet. Mechanisms of Ageing and Development. 2014, 136-137, 148-162.
28. Yannakoulia M, Kontogianni M, Scarmeas N. Cognitive health and Mediterranean diet: just diet or lifestyle pattern? Ageing Research Reviews. 2015, 20, 74-78.
29. Zaragoza-Martí A, Cabañero-Martínez M, HurtadoSánchez J et al. Evaluation of Mediterranean diet adherence scores: a systematic review. BMJ Open. 2018, 8, 2, e019033.
30. Trichopoulou A, Kouris-Blazos A, Wahlqvist M et al. Diet and overall survival in elderly people. BMJ. 1995, 311, 7018, 1457-1460.
31. Panagiotakos D, Pitsavos C, Stefanadis C. Dietary patterns: a Mediterranean diet score and its relation to clinical and biological markers of cardiovascular disease risk. Nutrition, Metabolism, and Cardiovascular Diseases. 2006, 16, 8, 559-568.
32. Valls-Pedret C, Sala-Vila A, Serra-Mir M et al. Mediterranean diet and agerelated cognitive decline: a randomized clinical trial. JAMA Internal Medicine. 2015, 175, 7, 1094-1103.
33. Petersson S, Philippou E. Mediterranean diet, cognitive function, and dementia: a systematic review of the evidence. Advances in Nutrition. 2016, 7, 5, 889-904.
34. Fernandes BS, Dean OM, Dodd S et al. N-acetylcysteine in depressive symptoms and functionality: a systematic review and meta-analysis. J Clin Psychiatry 2016;77:e457-e66.
35. Zheng W, Zhang QE, Cai DB et al. N-acetylcysteine for major mental disorders: a systematic review and meta-analysis of randomized controlled trials. Acta Psychiatr Scand 2018;137:391-400.
36. Breier A, Liffick E, Hummer TA et al. Effects of 12-month, double-blind N-acetyl cysteine on symptoms, cognition and brain morphology in early phase schizophrenia spectrum disorders. Schizophr Res 2018;199:395- 402.
37. Yolland CO, Phillipou A, Castle DJ et al. Improvement of cognitive function in schizophrenia with N-acetylcysteine: a theoretical review. Nutr Neurosci (in press).
38. Dean O, Giorlando F, Berk M. N-acetylcysteine in psychiatry: current therapeutic evidence and potential mechanisms of action. J Psychiatry Neurosci 2011;36:7886.
39. Reedy J, Krebs-Smith SM, Miller PE et al. Higher diet quality is associated with decreased risk of all-cause, cardiovascular disease, and cancer mortality among older adults. J Nutr 2014;144:881-9.
40. Wactawski-Wende J, Kotchen JM, Anderson GL et al. Calcium plus vitamin D supplementation and the risk of colorectal cancer. N Engl J Med 2006; 354:68496.
41. Jenkins DJ, Spence JD, Giovannucci EL et al. Supplemental vitamins and minerals for CVD prevention and treatment. J Am Coll Cardiol 2018;71: 257084.
42. Lonn E, Bosch J, Yusuf S et al. Effects of long-term vitamin E supplementation on cardiovascular events and cancer: a randomized controlled trial. JAMA 2005;293:1338-47.
43. Robertson S, Mountjoy M. A Review of Prevention, Diagnosis, and Treatment of Relative Energy Deficiency in Sport in Artistic (Synchronized) Swimming. Int J Sport Nutr Exerc Metab. 2018;28(4):375-384. doi:10.1123/ijsnem.2017-0329.
44. Barwais FA, Cuddihy TF, Tomson LM. Physical activity, sedentary behavior and total wellness changes among sedentary adults: a 4-week randomized controlled trial. Health Qual Life Outcomes. 2013;11:183. Published 2013 Oct 29. doi:10.1186/1477-7525-11-183.
45. Watkins BA. Endocannabinoids, exercise, pain, and a path to health with aging. Mol Aspects Med. 2018;64:68-78. doi:10.1016/j.mam.2018.10.001.

46. Santesteban Moriones V, Ibáñez Santos J. Ayudas ergogénicas en el deporte [Ergogenic aids in sport]. Nutr Hosp. 2017;34(1):204-215. Published 2017 Feb 1. doi:10.20960/nh.997.

47. Russell S, Jenkins D, Rynne S, Halson SL, Kelly V. What is mental fatigue in elite sport? Perceptions from athletes and staff. Eur J Sport Sci. 2019;19(10):1367-1376. doi:10.1080/17461391.2019.1618397.